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THE ROYAL SOCIETY

Protecting terrestrial ecosystems and the climate through a global carbon market

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Protecting terrestrial ecosystems through international environmental laws requires the development of economic mechanisms that value the Earth's natural systems. The major international treaties to address ecosystem protection lack meaningful binding obligations and the requisite financial instruments to affect large-scale conservation. The Kyoto Protocol's emissions-trading framework creates economic incentives for nations to reduce greenhouse-gas (GHG) emissions cost effectively. Incorporating GHG impacts from land-use activities into this system would create a market for an important ecosystem service provided by forests and agricultural lands: sequestration of atmospheric carbon. This would spur conservation efforts while reducing the 20% of anthropogenic CO_2 emissions produced by land-use change, particularly tropical deforestation. The Kyoto negotiations surrounding land-use activities have been hampered by a lack of robust carbon inventory data. Moreover, the Protocol's provisions agreed to in Kyoto made it difficult to incorporate carbon-sequestering land-use activities into the emissions-trading framework without undermining the atmospheric GHG reductions contemplated in the treaty. Subsequent negotiations since 1997 failed to produce a crediting system that provides meaningful incentives for enhanced carbon sequestration. Notably, credit for reducing rates of tropical deforestation was explicitly excluded from the Protocol. Ultimately, an effective GHG emissions-trading framework will require full carbon accounting for all emissions and sequestration from terrestrial ecosystems. Improved inventory systems and capacity building for developing nations will, therefore, be necessary.

Keywords: emissions trading; carbon sequestration; environmental treaties

1. Introduction

This paper examines the efficacy of existing international legal frameworks to protect terrestrial ecosystems, analyses the Kyoto Protocol's provisions governing the atmospheric impacts of land use and suggests improvements to Kyoto's market framework to further both conservation and protection of the climate. A single premise provides context for our entire analysis: protecting terrestrial ecosystems and the climate requires the development of economic institutions that value the Earth's natural

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systems. To be effective, international environmental laws must create mechanisms to finance protection of the climate and natural ecosystems.

We begin by examining the major international legal instruments that address ecosystem conservation. While we recognize the important contributions these treaties have made, we find in general that they lack the financial mechanisms necessary to catalyse environmental protection at a globally significant scale. We then turn towards market mechanisms, emissions trading in particular, and its potential to create incentives for cost-effective environmental protection.

We next undertake an extended discussion of the Kyoto Protocol's emission trading framework and the opportunity to weave land-based carbon-sequestration activities into the global market for greenhouse-gas (GHG) emissions-reduction credits. Land-use activities, particularly emissions from tropical deforestation, are an important part of the global carbon cycle. Including land-use activities in an international emissions-trading framework would provide a potentially cost-effective means to address climate change while providing significant ancillary environmental benefits.

The lack of robust carbon inventory data from the world's forests and agricultural lands hurt efforts to structure effective land-use provisions during negotiations in Kyoto in 1997. While the Kyoto Protocol will, if ratified, substantially advance environmental protection through market institutions, its land-use provisions are problematic. In particular, articles governing land-use activities in industrialized nations made it difficult in subsequent negotiations to create incentives for enhanced carbon sequestration and ecosystem protection without potentially undermining the stringency of Kyoto's emissions caps.

In Bonn and Marrakech in 2001, the Parties to the Protocol agreed upon rules implementing most aspects of the Kyoto framework. Broadly, the Parties preserved and strengthened the treaty. However, in the case of land-use activities, they failed to provide meaningful incentives for improved forest management in industrialized nations and missed a significant opportunity to use market mechanisms to address tropical deforestation.

We conclude by offering three recommendations for improving the structure and operation of the Kyoto Protocol's carbon-sequestration provisions. First, both industrialized and non-industrialized nations must invest in improved terrestrial carbon inventory systems. Second, for future commitment periods (2013 and beyond), the Protocol must require full carbon accounting (i.e. measurement and accounting for all land-based GHG emissions and sequestration) in all countries subject to emissions caps, thereby fully integrating land-use activities into the Kyoto framework. Full carbon accounting provides the most accurate accounting system, creates incentives for improved land management and will ensure that GHG emissions from loss and degradation of tropical forests are captured as developing countries adopt future emissions-reduction targets. Finally, developing countries need assistance to gain experience in reducing rates of deforestation while improving the livelihoods of their peoples before these countries can be expected to adopt emissions budgets under a full carbon accounting framework.

2. International environmental treaties

This section examines relevant provisions and programmes under the major biodiversity protection treaties, including the Convention on International Trade in Endan-

gered Species (CITES), the United Nations (UN) Convention on Biological Diversity (CBD), the United Nations Convention to Combat Desertification (UNCCD) and the Ramsar Convention on Wetlands. Our purpose is to comment on their success and limitations in establishing international frameworks that lead to the conservation of natural ecosystems.

(*a*) *The Convention on International Trade in Endangered Species*

The 1972 UN Conference on the Human Environment, held in Stockholm, launched the development of a major set of international environmental instruments. Foremost among these was CITES, adopted in 1973. CITES regulates, monitors and limits commercial international trade in endangered species. When first adopted, CITES was quite innovative in classifying species according to their degree of vulnerability and rarity and in tailoring restrictions accordingly (Bean & Rowland 1997). Lyster (1985, p. 240) calls CITES, in which some 150 nations now participate, 'perhaps the most successful of all international treaties concerned with the conservation of wildlife'. However, compliance with the treaty has faltered in several countries since the 1980s (Weiss & Jacobson 1999).

Parties to CITES regulate wildlife trade through controls on species listed in three appendices to the treaty. CITES requires each Party to adopt national legislation designating a national Management Authority, which issues permits for trade in listed species. CITES also requires each Party to designate a national Scientific Authority responsible for advising the Management Authority on the issuance of permits. Parties are required to maintain trade records and forward those annually to the CITES Secretariat, enabling the Secretariat to compile statistical information on the global volume of trade in listed species. The treaty is enforced through presentations of reports on alleged infractions; national authorities enhance CITES enforcement through cooperation with customs, police or appropriate agencies. Bean & Rowland (1997) note the lack of effective enforcement mechanisms and the resulting variance in how the treaty is implemented by different Parties.

While CITES has made substantial contributions to the protection of wildlife, the treaty's reach is necessarily limited. CITES focuses narrowly on international trade and, thus, on the direct taking (e.g. shooting, capturing) of endangered wildlife. While direct taking is an important contributor to the loss of species, the greatest threat to biological diversity is the destruction of habitat, particularly in species-rich environments such as tropical rainforests (Wilson 1992). Given its exclusive focus on trade, CITES has had limited impact on the conservation of habitat and hence the considerable loss of biodiversity attributable to habitat loss.

(*b*) *The UN Convention on Biological Diversity*

In 1987, the World Commission on Environment and Development released the Brundtland Report. Entitled '*Our common future*', the report emphasized the importance of sustainable development and catalysed the 1992 UN Conference on Environment and Development, held in Rio de Janeiro, Brazil, on the 20th anniversary of the Stockholm Conference. At Rio, nations signed not only the UN Framework Convention on Climate Change (FCCC), but also the CBD, negotiated under the auspices of the United Nations Environment Programme (UNEP). Within weeks of the Rio summit, over 150 nations had signed the CBD and it entered into force in

1993. Notably, the US did not ratify the CBD, arguing that its benefit-sharing provisions jeopardized private industry's claims to intellectual-property rights in products derived from ecosystems.

The CBD has three broad objectives: to promote (1) the conservation of biodiversity, (2) the sustainable use of its components and (3) the fair and equitable sharing of benefits arising out of the use of genetic resources. While the CBD is legally binding on contracting Parties, its provisions relating to a variety of measures (e.g. impact assessments, establishment of protected areas, etc.) typically require Parties to take actions 'as far as possible and as appropriate'. Importantly, unlike the more narrow focus of CITES, the CBD explicitly recognizes and seeks to address the primary cause of species loss: habitat destruction (Bean & Rowland 1997). The Conference of the Parties (COP) to the CBD and the CBD's Subsidiary Body on Scientific, Technical and Technological Advice (SBSTTA) develop recommendations on a wide range of habitats, including inland water systems, marine and coastal environments, agricultural systems and forests. Recommendations on biosafety have matured into a binding protocol on biosafety adopted by the CBD's COP.

Perhaps the most interest in the CBD has centred around the treatment of intellectual-property rights in bio-prospecting. Species hold great promise in providing undiscovered compounds that could advance medical science or prove useful to humans in other ways. As such, conservationists have been keenly interested in the prospects of financing the protection of biodiversity through the sale of intellectual-property rights to unique genetic compounds. The CBD does not seek to create new property rights in biodiversity, but does seek to help guide bio-prospecting through advocating, for example, equitable sharing of the proceeds from the discovery of important natural compounds. Equity, particularly the ability of local people to share in the proceeds from valuable compounds, has been one of the more prevalent criticisms of bio-prospecting (e.g. Parry 2001). Given the range of opinions on bio-prospecting, the CBD has had to pursue policies that accommodate those nations that view trade in intellectual-property rights as part of the threat to biodiversity and those who view it as a potential solution (Bean & Rowland 1997).

Whether intellectual-property rights can provide a stable and effective source of revenue for the creation and maintenance of protected areas remains to be seen. Various factors will dictate whether a meaningful market emerges, leading to large-scale conservation, including the likelihood of finding a major marketable compound or set of compounds in any particular region, the extent to which the active compounds can be synthesized in the laboratory, their usefulness, their marketability and the ability to capture proceeds from bio-prospecting for conservation. While some, most notably Costa Rica's INBio programme, have secured agreements with pharmaceutical companies that have yielded revenues for conservation activities, arrangements allowing for access to genetic resources and benefit sharing have not yet produced the capital necessary to affect conservation on a globally significant scale.

Indeed, the economics of bio-prospecting may not provide the incentive necessary for widespread conservation. Simpson (1997) argues, for example, that, given the vast numbers of species and regions from which to choose, pharmaceutical companies place a low value on protecting any single species. Because they can gain access to many species-rich areas, these companies have a seemingly limitless supply of potential compounds; in other words, they have access to many substitutes, and any one specific land area, therefore, has little value. Consequently, Simpson (1997)

argues, pharmaceutical companies have a low willingness to pay for land conservation even if the area is species rich and threatened. This observation suggests that conservationists should rely on other strategies to conserve natural ecosystems and that, therefore, the CBD's bio-prospecting provisions will be likely to have limited influence on the protection of habitat.

(*c*) *The UN Convention to Combat Desertification*

Desertification is an acute problem with grave human consequences in developing countries, particularly in Africa. The 1994 UNCCD uses a 'bottom-up' approach to combat desertification, on the assumption that involving people who are affected by desertification in decision making is most effective in addressing and mitigating the problem. The CCD was ratified in 1996 and now has 178 participating Parties.

The CCD is governed by a COP, and it also works via a Committee on Science and Technology (CST), which advises and meets simultaneously with the COP. At the CST's recommendation, the COP has established an ad hoc panel to oversee the continuation of the process of surveying benchmarks and indicators, and has undertaken consideration of linkages between traditional knowledge and modern technology.

Articles 4, 6, 20 and 21 of the Convention recognize the importance of financial mechanisms in confronting the problem, particularly since most of the countries affected by desertification have few resources of their own. The CCD establishes a Global Mechanism, whose function is to guide and channel resources to activities, programmes and projects combating desertification. The Mechanism is housed in the International Fund for Agricultural Development (IFAD), an agency of the UN, is funded by the COP and seeks to leverage funds from the Global Environmental Facility (GEF), The World Bank, other development banks and voluntary donor nations.

Given the complex nature of the problem, it may well be too early to pass judgement on the effectiveness of the CCD. The CCD has, particularly through the Global Mechanism, clearly focused financial resources and attention on the problem. One potential weakness of the CCD, however, could be its reliance on development banks, the GEF and other nations for funding that is in high demand from a host of other competing interests.

(*d*) *The Ramsar Convention on Wetlands*

The Convention on Wetlands, negotiated in Ramsar, Iran, in 1971, provides a framework for national action and international cooperation for the conservation of wetlands and, as such, was the first international treaty focusing on wildlife habitat. The Convention encourages Parties to ensure the wise use of wetlands, though there are no associated legal obligations to do so. The Parties meet periodically to establish a Convention work plan and to review wetland conservation efforts. Most importantly, the Ramsar treaty establishes the List of Wetlands of International Importance (the 'Ramsar list'). Parties commit to designate at least one wetland to the list and to ensure the maintenance of the ecological character of each listed site. One hundred and thirty nations are Party to the treaty and over 1100 sites covering almost 88 million hectares have been included on the Ramsar list. Criteria for listing include, *inter alia*, the presence of rare species, important wildlife populations and unique wetland types.

A wetland's inclusion on the Ramsar list may boost efforts to protect it. Lyster (1985) provides several examples of wetlands whose status on the Ramsar list increased the political pressure for national action to conserve the sites. Other listed wetlands have not fared so well. Indeed, Ramsar includes no binding obligation to protect any listed site. Further, it contains no financial mechanism to fund conservation, the absence of which may make it particularly difficult for developing countries to conserve listed wetlands (Lyster 1985). Such a mechanism might also help to finance protection of wetlands in industrialized nations where opportunity costs of conservation are high.

At the eighth meeting of the Conference of the Ramsar Parties, to be held in Spain in November 2002, the Parties will consider, among other things, the use of economic incentives to protect wetlands. However, it appears likely that the conference will merely encourage Parties to adopt domestic incentive measures for wetlands conservation and to reiterate the need to repeal perverse incentives that encourage the destruction of wetlands (Ramsar Convention on Wetlands 2002). Thus Ramsar's most significant contribution to wetlands protection will continue to be focusing international attention on the importance of particular recognized sites. In the absence of legal obligations or comprehensive financing, such an approach will be limited in its effect.

(*e*) *Towards a market for ecosystem services*

CITES, CBD, CCD and Ramsar have each been successful in creating international institutions and, in some cases, bolstering national efforts to protect biodiversity and natural resources. However, these treaties suffer from a lack of binding obligations (CITES excepted), and from the absence of meaningful funding mechanisms. Of the four treaties discussed, the CBD, though we are pessimistic about its potential to effect significant conservation, is instructive in two important ways. First, while bio-prospecting is unlikely to steer substantial financial resources towards ecosystem protection, the CBD is daring in its effort to harness (or, at least, to help direct) private capital for conservation. Governments in industrialized nations will continue to fund environmental protection in varying degrees, but the potential of private businesses to do the same, particularly in the developing world, could be enormously important.

Second, the CBD's provisions related to genetic resources acknowledge the value of the unique services, in this case useful chemical compounds, provided to humans by natural systems. There is growing interest in valuing, through market mechanisms, the services provided by natural ecosystems, and there are many emerging applications of market solutions, including trade in water rights to benefit rare fish (Willey 1992), banking of endangered species habitat (Bonnie 1997) and certification of sustainably grown wood products. Likewise, in the context of GHG emissions, the creation of property rights in the form of these tradable commodities could potentially provide financial incentives for the conservation and improved management of ecosystems at a globally significant scale.

3. Emissions trading: theory and practice

In 1990, the US began what amounted to a large-scale experiment with emissions trading, a concept that economists had discussed for years, but which was largely

untested. The acid-rain programme, Title IV of the Clean Air Act Amendments of 1990, employed for the first time a cap-and-trade framework to halve sulphur dioxide emissions over a large geographic region.

While a traditional command and control regulatory approach mandates particular emission reductions by each source or use of a particular pollution control technology, emissions trading mandates only a fixed limit on aggregate emissions by the regulated sector. Under a cap-and-trade system, each unit of allowable emissions is associated with a permit, or allowance, that authorizes the bearer to emit that unit of emissions. Individual sources may buy or sell these emission allowances, but must tender for compliance allowances equal to their actual emissions. If a source can reduce emissions below its cap, then the surplus reductions may be banked or sold to another source, thereby creating economic incentives for surplus emissions reductions.

Similarly, under the Title IV system, the US Congress set a cap on sulphur dioxide emissions, allocated allowances to utilities on the basis of historic emissions, required utilities to possess one allowance for each ton of sulphur dioxide emitted each year and allowed them to buy, sell or bank allowances. If a utility's emissions exceed the number of allowances held, a stiff penalty of more than $2000 per ton of excess emissions is imposed, and the utility must surrender allowances equal to the number of tons of excess emissions (USEPA 2001*a*). The programme has resulted in 100% compliance and, through 1999, has seen an average of 22% over-compliance due to the banking provisions, resulting in greater emissions reductions than legally required (USEPA 2001*b*; Swift 2000). Allowance prices have averaged approximately $150 per ton (USEPA 2001*b*; Swift 2000; Ellerman *et al.* 2000), well below anticipated costs of $300–$1000 per ton (Hahn & May 1994).

Three critical elements of the Title IV programme account, in large part, for its success. First, the programme specifies a mandatory ('hard') cap on emissions in the regulated sector. Alternatives such as rate-based emissions caps, for example, or caps on emissions that limit the price of allowances will typically allow emissions to rise indefinitely into the future (Weitzman 1974; Baumol & Oates 1988). Second, emission units must be fully fungible and bankable into the future. If allowances cannot be banked for future use, businesses will seek to use all of them before they expire, thereby increasing actual emissions. With banking, however, sources have a strong economic incentive to reduce emissions below the level needed for compliance (Ellerman *et al.* 1997, 2000). Third, any legitimate cap-and-trade system must contain provisions to ensure strict compliance with the cap, including transparent measurement and reporting of emissions and penalties that are sufficiently high so that sources do not opt to exceed the cap and simply accept the penalty or fine associated with non-compliance (Ellerman *et al.* 1997, 2000; Swift 2000).

4. The Kyoto Protocol and emissions trading

The Kyoto Protocol places legally binding limits or caps on the emissions of six GHGs from 31 industrialized nations for the five-year period 2008–2012 (UNFCCC COP 1997). Nations with emissions caps are listed in Annex B of the Protocol and are frequently referred to as 'Annex-B Parties'. The Protocol implements its legally binding commitments by issuing Annex-B Parties emissions budgets denominated in 'assigned amounts' of GHG emissions allowances for the five-year period. These

budgets are calculated from the baseline of the nations' GHG emissions in 1990. For example, under the Protocol, member states of the European Union adopted emissions budgets for the 2008–2012 period at levels 8% less than their 1990 emissions. The Russian Federation adopted an emissions budget set at a level equal to its 1990 emissions. Annex-B Parties are required to ensure that their actual emissions do not exceed their emissions budgets. In the 2001 Marrakech Accords, the Parties signalled their intent to require that any Party exceeding its emissions budget at the end of 2012 must surrender emissions allowances in the next commitment period in an amount equal to excess emissions multiplied by a factor of 1.3 (UNFCCC COP 2001).

The Protocol includes four market-based mechanisms that may be used by nations to meet their emissions caps during the compliance period: emissions trading among nations with emissions caps, joint investment projects in nations with caps, reductions from joint investment projects in uncapped nations through the Protocol's Clean Development Mechanism (CDM), and reallocation of targets among groups of nations (UNFCCC COP 1997). Using these mechanisms, a nation with a cap on emissions may meet the requirements of the Kyoto Protocol in several different ways: it may adjust its emissions cap up or down by trading units of the cap with another capped nation (international emissions trading and reallocation of targets), by undertaking a project with another capped nation to reduce emissions within that nation's borders (joint implementation), or by undertaking a project to reduce emissions in an uncapped nation below what would have otherwise occurred (CDM).

The Kyoto Protocol also includes provisions for the inclusion of GHG emissions and sequestration from land-use activities in its emissions-trading framework. Before we turn to an explanation of those provisions, we first explain the rationale for including land-use activities in an international treaty addressing climate change. We then address the challenges of incorporating land-use activities in a GHG emissions-trading framework. Only then do we turn to the treatment of land-use activities in the Protocol.

5. Valuing the ecosystem services of forests

(*a*) *Global carbon cycle*

Land-use activities, and the management of forests in particular, have a significant effect on concentrations of GHGs in the atmosphere. Terrestrial ecosystems are estimated to provide a sink (or flux out of the atmosphere) of $2.3 \pm 1.3\ \mathrm{GtC\ yr^{-1}}$ (IPCC 2000). A significant proportion of this carbon sink results from the regrowth of forests in the Northern Hemisphere (Caspersen *et al.* 2000). Emissions from land-use activities, primarily tropical deforestation, on the other hand, are estimated to be $1.6 \pm 0.8\ \mathrm{GtC\ yr^{-1}}$ (IPCC 2000).

When tropical forests are clearcut, burned or destroyed, a significant proportion of the carbon stored in leaves, wood and soils is emitted into the atmosphere as carbon dioxide. Globally, 14.2 million hectares of tropical forest are lost annually (Food and Agricultural Organization of the United Nations 2001). Using IPCC data, emissions from land-use change, primarily tropical deforestation, comprise *ca.* 20% of total anthropogenic carbon dioxide emissions, and are comparable to CO_2 emissions from fossil-fuel combustion in the US, the world's largest emitter of GHGs (figure 1).

The contribution of tropical deforestation to climate change is equally dramatic when compared with the contributions from combustion of petroleum, coal and nat-

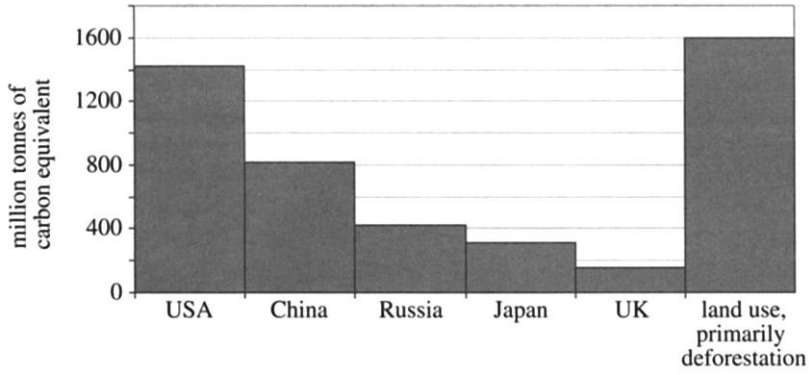

Figure 1. Comparison of mean annual deforestation emissions (1989–1995) to fossil-fuel emissions from major emitting countries (1995). Source: UNEP (1996); IPCC (2000).

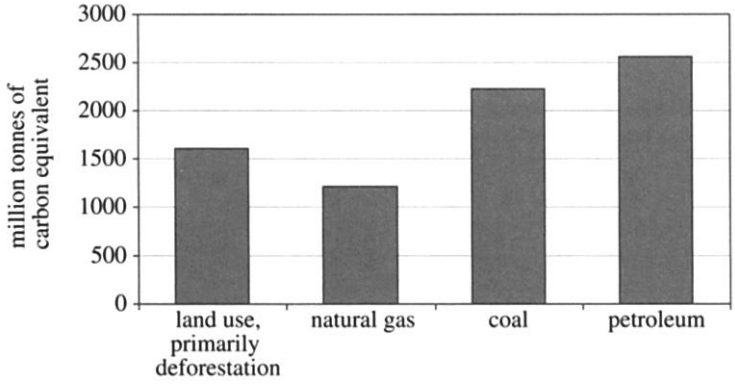

Figure 2. Comparison of mean annual deforestation emissions (1989–1995) to emissions from petroleum, natural gas and coal (1990–1999). Source: IPCC (2000); US Department of Energy (1999).

ural gas (figure 2). Thus addressing tropical deforestation must be fundamental component of an effective international climate policy.

(*b*) *Ecosystem services provided by terrestrial ecosystems*

Terrestrial ecosystems provide enormous benefits to society (Costanza *et al.* 1997), including carbon sequestration, watershed protection, erosion control, biodiversity conservation and others. Yet the traditional marketplace has typically proven inadequate at valuing ecosystem services (Bonnie *et al.* 2000). For example, forestlands typically have market values for the production of wood products or for the supply of potential agricultural land. Capturing these values requires harvesting timber or converting the forest to cropland or rangeland, both of which diminish at least some of the ecosystem services otherwise produced. Because markets do not yet broadly exist for ecosystem services, forest owners are often unable to reap financial rewards from conservation activities or non-consumptive uses of forests.

Creating a marketable value for the GHG benefits of standing forests would provide a potentially powerful incentive for forest protection. Further, in many ecosystems, valuing GHG benefits would serve as a useful proxy for the other ecosystem

services produced by the ecosystem. Protecting carbon stores in mature tropical rainforests, for example, simultaneously protects a diversity of wildlife species that use the rainforest. Kremen *et al.* (2000) demonstrated that if monetary compensation were given for reduced carbon emissions from curtailed deforestation in Madagascar, forest preservation would become a financially profitable endeavour for that country relative to timber harvest. Other non-forest-carbon-sequestration activities such as grassland restoration and conservation-tillage practices can increase carbon stocks while also providing ancillary environmental benefits such as erosion control and wildlife conservation. GHG emissions-trading systems that incorporate land-use activities have the potential to alter the way ecosystems are valued in a potentially significant way.

Many potential participants in such a market have already begun to explore opportunities for purchasing GHG offsets in the land-use sector. BP, American Electric Power and other companies, in partnership with The Nature Conservancy (an NGO), have invested approximately $10 million in a project to preserve 600 000 hectares of Bolivian rainforest. The project is anticipated to provide substantial GHG emissions reductions through reduced rates of deforestation in the region. In the US Mississippi River Delta, electric utilities have funded reforestation and permanent retirement of marginal agricultural lands, providing atmospheric benefits, improved water quality and enhanced wildlife habitat, including for the Louisiana black bear (*Ursus americanus luteolus*), a threatened species. McCarl & Schneider (2001) examined the potential of US farmers to respond to a market for carbon-sequestration credits. At a price of $50 per tonne of carbon, farmers would in time produce over 150 million tonnes of carbon equivalent in annual sequestration through changes in cropping practices, reforestation of cropland and other activities.

While carbon-sequestration activities generally provide substantial ancillary environmental benefits, there are instances where such activities may result in undesirable land-use practices. Poorly designed sequestration rules, for example, could allow for the 'off-book' liquidation of mature forests, with resulting emissions being unaccounted for, and then 'on-book' replacement, for credit, with younger trees. This threat, however, is easily solvable with rules that require establishment of carbon stock baselines based on historic data prior to forest liquidation.

A more difficult issue relates to fire-adapted ecosystems. Fire suppression in such ecosystems can increase carbon stores in the short term through an increase in a forest's shrub layer. However, fire suppression appears to be a very risky medium- to long-term sequestration strategy, as it increases the odds of catastrophic fires and the resultant significant GHG emissions. Nonetheless, the effect of carbon crediting on fire-adapted ecosystems bears watching.

Socio-economic issues are also an important consideration in the establishment of carbon markets, particularly in developing countries where land tenure regimes may be ill defined. Without appropriate safeguards, local residents may not benefit financially from market transactions. As with bio-prospecting, equity is an important issue both from an ethical standpoint and a practical one as support from local populations is important to ensure that conservation measures are enduring. With appropriate safeguards to protect land tenure of local people, however, local populations could stand to gain significantly from a carbon market.

The additional non-atmospheric benefits associated with carbon-sequestration activities tend to be quite positive. Emissions trading offers the possibility of placing

a marketable value on the ecosystem services provided by improved land-use practices, thereby creating incentives for the conservation of biodiversity, watersheds and soils.

6. Incorporating land-use activities in an emissions-trading framework

While there is a compelling environmental rationale for the inclusion of land-use activities in a GHG emissions-trading framework, two fundamental issues must still be addressed. First, can carbon stock changes in forests, vegetation and soils be accurately measured? Second, are credits produced in the land sector fully fungible with emissions-reduction credits produced through other means?

Land-based carbon stocks can be measured through statistical analyses of direct measurements in forests, vegetation and soils. In forest projects, measurement costs have been reported as low as $0.28 per tonne of carbon with precision levels greater than 95% (Kadyszewski 2001). However, many countries do not currently have a nationwide measurement system with the precision necessary to provide for emissions trading. While project-based activities are still an option, the absence of comprehensive, national carbon-measurement systems in many countries remain a significant obstacle to fully incorporating land-use activities in an international emissions-trading systems.

For a market to operate effectively, carbon-sequestration credits must not only be measurable, they must also be fungible with credits produced in other sectors of the economy. During the negotiations surrounding inclusion of land-use activities in the Kyoto Protocol, the question of fungibility was intensely debated, and centred largely on the reversibility, or so-called permanence, of carbon stocks. The IPCC notes that 'enhancement of carbon stocks resulting from land use, land-use change and forestry activities is potentially reversible through human activities, disturbances, or environmental change, including climate change' (IPCC 2000, p. 9).

The potential reversibility of carbon stocks requires on-going monitoring of carbon stocks that are included in an emissions-trading framework. If carbon stocks that have been credited in the system are later re-released, then they must be replaced from some other source. It matters not whether sequestration activities enter the market through project-based activities or a comprehensive nationwide measurement system. As long as all emissions of credited carbon stocks are accounted for and required to be replaced when lost, then the potential reversibility of carbon stocks will affect neither a nation's emissions cap nor atmospheric concentrations of GHGs. The requirement for ongoing measurement and liability of credited carbon stocks in the land-use sector will add to the costs of carbon-sequestration activities. Nonetheless, such an accounting system effectively renders moot any obstacle to emissions trading based on the reversibility of land-based carbon stocks.

7. The Kyoto Protocol's carbon-sequestration framework

The Parties to the Kyoto Protocol were, and still are, sharply divided on the appropriate role of carbon-sequestration activities in the Protocol. Adding to the political complexity, the negotiations have been plagued by a dearth of information regarding

the magnitude of emissions and sequestration in the land-use sector in both industrialized and non-industrialized nations. In negotiating the Kyoto Protocol in 1997, negotiators had little information on net sequestration rates for Annex-B Parties, which made it difficult for climate negotiators to assess the impacts of including land-use activities in emissions budgets established in Kyoto. Since 1997, there are still significant gaps in the quality of carbon inventory data. This lack of scientific data was clearly detrimental to negotiations in Kyoto, The Hague, Bonn and Marrakech.

(*a*) *Article 3.3: afforestation, reforestation and deforestation*

Article 3.3 of the Protocol requires Annex-B Parties to account for net emissions (or sequestration) from afforestation, reforestation and deforestation since 1990. Accounting under Article 3.3 is highly dependent upon the definitions of these three activities. For example, a definition of reforestation that includes re-establishment of a forest following timber harvest combined with a definition of deforestation that excludes emissions from timber harvesting would allow countries with large areas of managed forest land to receive a large volume of credit towards meeting their emissions budget without having to account for the emissions associated with harvesting. Such accounting anomalies could occur through a variety of definitional scenarios.

Alternatively, a system that requires accounting for carbon stock changes for land-use changes only (conversions of forest land to non-forest land and vice versa) would yield a framework that is most representative of atmospheric changes in GHGs resulting from afforestation, reforestation and deforestation. Even this interpretation of Article 3.3 could lead to some counterintuitive outcomes. For example, an Annex-B Party with roughly equal amounts of deforestation and reforestation (and, thus, a relatively stable forest land base) would be likely to have net emissions under Article 3.3, because deforestation of mature forests results in significant pulses of emissions, while afforestation and reforestation activities result in small sequestration gains because the volume of annual sequestration in young forests is low. More broadly, Article 3.3 produces this anomaly because it only accounts for a small portion of the forest-management activities affecting carbon-sequestration rates in Annex-B countries. Accurately capturing the atmospheric fluxes of GHGs resulting from land-use activities requires comprehensive accounting.

(*b*) *Article 3.4: other sequestration activities*

Beyond afforestation, reforestation and deforestation, the Kyoto Protocol failed to resolve whether and how other land-use activities would be treated in Annex-B countries. Article 3.4 of the Protocol directs the negotiators to decide upon rules by which the inclusion of 'additional human-induced activities related to changes in greenhouse gas emissions by sources and removals by sinks in the agricultural soils and the land-use change and forestry categories' in the Protocol could be 'added to, or subtracted from' an Annex-B Party's assigned amount. Thus treatment of land-use activities under Article 3.4 could have potentially significant implications for the assigned amounts of Annex-B nations. This can best be illustrated with a practical example. Here, we use the case of the US. Though the current US Administration has chosen not to participate in the Protocol, the case of the US nonetheless provides insight into the problems inherent in Article 3.4.

Table 1. *Ramifications of including land-use activities under Article 3.4 on the GHG emission reductions required by the US during the first commitment period of the Kyoto Protocol*

(Units are million metric tonnes of carbon equivalent (MMTCE).)

US allowable emissions under Kyoto Protocol (USEPA 2001*b*)	annual US fossil-fuel emissions 2008–2012	projected reductions under Kyoto Protocol	projected business-as-usual sink under Article 3.4	required reductions met with BAU sinks
1530	2039–2139	509–609	310	51–61%

Table 1 depicts the potential impact of inclusion of all land-use activities under Article 3.4 on the effective reductions required by the US to comply with its assigned amount. Allowable annual GHG emissions for the US under the Kyoto Protocol during the first commitment period (2008–2012) are 1530 million tonnes of carbon equivalent (MMTCE) (based on figures from the USEPA (2001*b*)). Under an assumed annual emissions growth of 1.2%, the US would emit *ca.* 2039–2139 MMTCE annually from 2008–2012, thus requiring annual reductions of 509–609 MMTCE to meet its Kyoto target. Prior to climate negotiations in The Hague in 2001, the US projected mean net carbon sequestration in the land-use sector of 310 MMTCE for the years 2008–2012 under business-as-usual assumptions (i.e. no substantial change in current US land-management practices). Consequently, by including all carbon-sequestration activities under Article 3.4 without any restrictions, the US could, through business-as-usual practices in the land sector, meet 51–61% of its required emissions reductions.

This outcome results not from inherent problems associated with accounting for land-use activities under an international framework, but instead from the architecture of the Kyoto Protocol and, especially, Article 3.4 itself. The Kyoto Protocol did not require Parties to include emissions and sequestration from land-use activities (other than from a limited set of agricultural activities, see Kyoto Protocol Annex A) in the calculation of their 1990 base year emissions (unless their land-use change and forestry in 1990 constituted a net source, see Kyoto Protocol Article 3.7). Thus, when the Protocol provided that the allowable total GHG emissions budgets for Parties would be set as a multiple of the base year emissions, emissions and sequestration from land-use activities were not subject to a baseline. Had the data been available on carbon stocks in Annex-B countries and had negotiators agreed to account for GHG sequestration (or emissions) from all land-use activities, then the targets might have been structured quite differently. Countries with large net sequestration would be likely to have been pressured to lower their targets substantially in order to reflect the expected sequestration. That clearly did not happen and, given the paucity of data, could not have happened in Kyoto.

Instead, the emissions budgets established in Kyoto did not explicitly recognize the potential contribution of business-as-usual land-use trends in Annex-B countries, and Article 3.4 left open the question of whether and how land-use activities would be treated. As such, efforts to include sequestration activities in Article 3.4 were viewed by many as an attempt to weaken the Kyoto targets. It is important to

note, however, that the inclusion of sequestration activities in Article 3.4 could also stimulate enhanced sequestration through an emissions-trading framework.

Negotiators focused on two approaches for limiting the impact of Article 3.4 activities on the Kyoto emissions budgets. The first approach was to limit the activities that would be eligible under Article 3.4. For example, narrowly defined activities, such as reduced-impact logging, grassland restoration and use of cover crops in croplands, would necessarily reduce the impact of Article 3.4 on emissions budgets because of these activities would result in fewer tonnes of carbon entering the system. But, as negotiators realized, such activities would face the same definitional problems noted in our earlier discussion of Article 3.3. Defining narrow activities would be difficult and could lead to gaming by nations that hoped to exclude emissions in the land-use sector while accounting only for sequestration activities (IPCC 2000).

The second approach to limiting the impact of Article 3.4 on the Kyoto was to focus on an over-arching limitation across all Article 3.4 activities. Three general variants of this approach were discussed: discounting, cap and 'threshold' methods. All three would limit the impact of Article 3.4 activities on the Kyoto targets, but each would create quite different incentives with respect to the management of the land-use sector.

The first option, discounting, would reduce all carbon-sequestration credits earned under Article 3.4 by some percentage (e.g. 90%). Discounting would reduce total sequestration tonnes markedly but would also dramatically reduce incentives for Annex-B nations to adopt policies that would enhance carbon sequestration. The second option, a cap, would place a numerical cap on the number of tonnes that Annex-B nations could earn under Article 3.4. Like discounting, a cap can create perverse incentives depending upon the level at which the cap is set. For example, assume an Annex-B nation is projected under business-as-usual trends to sequester 10 MMTCE of carbon annually through Article 3.4. If a cap were placed at 5 MMTCE for this nation, its entire allotment of carbon-sequestration credits would be fulfilled with business-as-usual sequestration, leaving neither room nor incentive for the country to adopt policies to further enhance its carbon stores.

The third option, a threshold approach, would provide a more environmentally beneficial way to limit credit under Article 3.4, if the threshold is set appropriately. Under this approach, an Annex-B country would only be allowed to claim credit for sequestration activities after surpassing some threshold level of carbon storage. For example, an Annex-B country might be assigned a threshold of 5 MMTCE, meaning that it would only receive credit for sequestration tonnes produced beyond this threshold amount. The threshold method would limit the amount of credit that can be claimed by Parties for carbon sequestration produced under business-as-usual projections, while maintaining incentives for countries to undertake additional activities to increase carbon stores.

The choice of policy instruments to limit crediting under Article 3.4 has significant ramifications for the effective stringency of the Kyoto targets and for the incentives provided to Annex-B nations to manage their forests and agricultural lands. As we will elaborate more fully below in our discussion of the Bonn and Marrakech Accords, it was the structure of Article 3.4 and the different political and economic aims of the negotiating Parties, rather than anything inherent in the nature of carbon sequestration, that made it difficult for negotiators to find a solution that both

preserved the stringency of the Kyoto targets and maintained incentives for improved carbon management in the land-use sector.

(*c*) *Article 12 and tropical deforestation*

The world's tropical rainforests are concentrated in Latin America, Africa and southeast Asia, regions not represented in Annex B of the Protocol. Thus Articles 3.3 and 3.4, which apply only to Annex-B nations, will not, in large part, affect the substantial GHG emissions from tropical deforestation during the first commitment period. However, if non-industrialized nations are subject to emissions budgets in subsequent commitment periods under the Kyoto Protocol, as one would expect, treatment of carbon-sequestration activities under Articles 3.3 and 3.4 will become a crucial factor in determining whether or not emissions from deforestation are indeed addressed in a comprehensive manner.

In the short term, tropical deforestation can only be addressed through Article 12 of the Kyoto Protocol, the CDM. Article 12 itself does not explicitly include or exclude land-use projects from eligibility. As such, inclusion of land-use projects in the CDM was hotly contested following the negotiations in Kyoto.

Under Article 12, industrialized nations may purchase 'certified emissions reductions' (CERs) from non-Annex-B nations. CERs are generated through projects that reduce emissions below what would have occurred in the absence of the project. In the case of tropical deforestation, this could potentially allow for projects designed to reduce rates of deforestation in the tropics, financed by the sale of CERs.

By definition, the CDM allows emissions trading between Annex-B nations (with emissions caps) and non-Annex-B nations (without emissions caps). The challenge in trading between sources in capped nations and sources in uncapped nations is in ensuring that reductions from uncapped nations, are, in fact, real. This requires accounting for two key factors. First, guidelines must be established to select an emissions (or sequestration) baseline from which to measure emissions reductions. Article 12 requires that CERs be issued only if 'reductions in emissions... are additional to any that would occur in the absence of the certified project activity'. This so-called 'additionality' provision requires project proponents to establish 'without-project' emissions baselines against which emissions reductions are measured. In the case of tropical deforestation, this would require the projection of without-project deforestation rates for the project area. Establishing such baselines should not be overly challenging, since tropical deforestation is a relatively predictable phenomenon (Bonnie *et al.* 2000).

Second, trading between capped and uncapped nations can result in leakage of GHG benefits if the project activities cause a shift of emissions-producing activities to areas outside the project boundaries. In the case of the forest sector, leakage could occur when timber harvesting is reduced on one tract, but the reduction of timber supply causes increased harvests on other forest land, thereby nullifying any gains to the atmosphere. To ensure that projects with uncapped nations result in real GHG reductions, project proponents must measure and account for leakage in calculating creditable GHG emissions reductions.

Most importantly, neither the challenge of baseline calculation nor the issues associated with leakage pertain solely to carbon-sequestration projects. They are characteristic instead of all emissions-reduction projects in uncapped nations and, thus, provide no rationale for excluding land-use activities from Article 12.

8. Treatment of land-use activities under the Bonn and Marrakech Accords

Adoption of the Kyoto Protocol in 1997 provided only a bare framework for the treatment of land-use activities. Significant unresolved issues remained, requiring decisions by the Parties ultimately resolved in Bonn and Marrakech. With respect to Article 3.3, negotiators were to decide upon definitions of afforestation, reforestation and deforestation. Negotiators also had to decide which activities to include under Article 3.4 and how to mitigate the impact of the provision's potential impacts on the stringency of the Kyoto targets. Lastly, the Parties had to decide whether or not carbon-sequestration projects would be eligible under the CDM.

The negotiations in Bonn and Marrakech were successful on many fronts in solidifying the emissions-trading framework in the Protocol and thereby promoting the potential establishment of an international market in GHG emissions-reduction credits. Unfortunately, the rules adopted for the carbon-sequestration provisions of the Protocol missed a number of opportunities to create positive incentives for countries to improve their environmental performance for the management of forests and agricultural lands. In some cases, the rules adopted encourage precisely the opposite behaviour.

Parties adopted definitions under Article 3.3 that account for the GHG emissions and sequestration from afforestation, reforestation and deforestation only in the context of land-use conversions. As such, the rules provide an accounting system that accurately reflects the atmospheric impacts from these three activities. However, as noted below, any such incentive to increase carbon stores provided by the elaboration of these definitions is greatly reduced by the treatment of forest management in Article 3.4.

Under the Bonn and Marrakech Accords, Article 3.4 allows Annex-B parties to elect to account for the GHG impacts from forest management, cropland management, grazing-land management and revegetation. Inclusion of the first three of these activities moves the Protocol towards a comprehensive accounting framework that avoids gaming, leakage and definitional problems associated with more narrowly defined activities. The inclusion of revegetation as an eligible activity, however, is problematic. The term appears intended to include re-establishment of non-forest vegetation in areas that do not meet the minimum specifications that define a forest. However, the exclusion of 'devegetation' as a required eligible activity for parties electing to include revegetation under Article 3.4 means that emissions associated with the clearing of such lands will not be recorded.

A far more serious problem is the method chosen to limit the amount of credit that Annex-B Parties can claim under Article 3.4. The Parties chose to place country-specific caps on the forest-management activities of all Annex-B nations. As noted earlier, a cap on forest sector crediting under Article 3.4 would be very likely to exclude credit for activities undertaken during the commitment period that enhance carbon sequestration. The effect of a cap, therefore, is at once to reduce the stringency of the Kyoto targets while robbing Annex-B nations of any incentive to increase carbon storage in the forest sector.

Ironically, in the case of cropland and grazing-land management, negotiators elected to apply the threshold method of accounting. The threshold chosen is the sequestration rate for that Party in 1990. This provision maintains incentives for

Parties to adopt policies that increase sequestration rates in the agricultural sector. Such an approach would have been environmentally preferable for forest-management activities under Article 3.4.

The perverse incentive for forest-management activities under Article 3.4 is made worse by two other provisions in the Bonn and Marrakech Accords. First, if a Party has excess forest-management sequestration after application of cap in Article 3.4, it may use those tonnes to cover any deficit it incurs in Article 3.3 up to 9 MMTCE annually. As such, nations with projections of sequestration in the forest sector that exceed the cap on Article 3.4 have little incentive to reduce rates of deforestation or increase rates of reforestation and afforestation.

Second, in Marrakech, Parties agreed to prohibit banking of unused forest-management tonnes in Article 3.4 (that is, unused tonnes in excess of the cap). The absence of banking is damaging both to forests and the climate. For example, assume a Party expects to have 10 MMTCE of unused forest-management tonnes after accounting for its Article 3.4 cap. With banking, the country has an incentive to ensure that it, in fact, produces those unused tonnes during the commitment period as they have value in subsequent commitment periods. Without banking provisions, no such incentive exists and, arguably, the nation might benefit by speeding forest harvests now, because it will not be penalized for lowering its forest-management sequestration to the level of the cap. Moreover, harvesting those forests earlier would enable the Party to earn credits for the regrowth of carbon stocks in regenerated areas in subsequent periods. Of course, many factors will dictate whether such forest liquidation does indeed occur, including the domestic policies of Annex-B countries in implementing the Protocol, forest products markets, forest ownership patters and others. Regardless, the incentives created by the rules governing Article 3.4 are very troubling.

Parties also chose to exclude projects addressing tropical deforestation from the CDM, seriously hampering efforts to address the *ca.* 20% of global CO_2 emissions from this source. The decision to forgo a potentially powerful financial incentive to value the ecosystem services associated with the conservation of tropical rainforests is perhaps the most vexing to advocates for tropical forest protection.

Making sense of the Marrakech decisions is difficult, but one factor in particular appears to have contributed substantially to the decision-making process of all Annex-B nations. All Annex-B Parties sought, for different reasons, certainty as to the number of available credits that could be garnered through carbon-sequestration activities. Some desired certainty that sequestration tonnes would be limited; others desired certainty that they would receive a specified number of sequestration tonnes. A country's particular stance on carbon sequestration was driven in part by whether it expected to be a net seller or net purchaser of emissions-reduction credits under the Protocol. For countries that expect to purchase emissions-reduction credits on the international market, a cap allowing credit of tonnes expected under business-as-usual trends provides certainty that they will receive a certain number of tonnes through Article 3.4 and will, therefore, have an easier job complying with the Protocol. These net purchasers also probably realized that there was no easy way to predict the number of sequestration tonnes that would be available for purchase under the CDM. Consequently, these net purchasers were not adamant in their support for the inclusion of projects addressing tropical deforestation in the CDM.

Nations that might be net sellers of emissions-reduction credits may have sought more guaranteed tonnes under Article 3.4 in order to ensure a predictable revenue stream. It was also in the interest of these countries to restrict tonnes entering the market from the CDM. Given the enormous GHG emissions from tropical deforestation, excluding such projects would make economic sense by restricting the supply of available credits on the world market and thereby receiving a higher price for their tonnes.

Those countries who stood to gain little from a liberal interpretation of Article 3.4, and who expected not to have to rely on carbon-sequestration tonnes for compliance, typically sought during the negotiations to limit the number of forest-management tonnes that other nations could use. A potential reason for this is that doing so would boost their economic competitiveness relative to other nations, as they could spend less national income on compliance with Kyoto. A cap under Article 3.4 and exclusion of projects addressing tropical deforestation in the CDM provided them with certainty that sequestration tonnes used by other nations would have an absolute limit.

Of course, nations may have been swayed by other factors than self-interest, though the above explanation is consistent with the positions of most Annex-B nations. In any case, the shortcomings of the decisions made in Bonn and Marrakech are likely to increase the costs, reduce the environmental effectiveness and potentially weaken forest protection under an otherwise well-designed emissions-trading framework under the Kyoto Protocol.

9. Creating an emissions-trading framework that protects biodiversity and the atmosphere

The Bonn and Marrakech Accords failed to develop rules for land-use activities that create positive incentives for management of terrestrial sinks in Annex-B and non-Annex-B countries. Emissions from land-use activities have contributed significantly to climate change. Recognizing that improved land-management practices and, in particular, effective measures to reduce rates of deforestation are critical to overall efforts to reduce GHG emissions, how can the Kyoto framework be improved to create incentives for enhanced carbon sequestration and reduced GHG emissions through improved land management?

(*a*) *Compilation of comprehensive scientific data*

An effective emissions-trading system requires comprehensive data on GHG emissions and sequestration. The Kyoto negotiations on carbon-sequestration activities have taken place in the absence of robust data on terrestrial carbon stocks from Annex-B nations. Annex-B nations must improve their carbon-measurement systems. Equally importantly, non-Annex-B nations must begin to develop better inventory systems, especially if the Protocol is to adequately address tropical deforestation. Such inventory systems in developing countries could be financed by industrialized nations in exchange for GHG credits produced through carbon-sequestration activities.

(*b*) *Move towards mandatory full carbon accounting for all nations*

A system of full carbon accounting (FCA) measures all changes, positive and negative, in all carbon stocks from all lands continuously. Under FCA, once lands enter the emissions-trading system, all carbon stocks on those lands are monitored permanently over contiguous commitment periods. FCA works within an emissions-trading framework because ultimately the atmosphere does not differentiate (and neither should climate policy) between carbon dioxide molecules produced by fossil-fuel combustion and such molecules produced through forest destruction. FCA is the only way to provide a balanced accounting system that accurately reflects the relationship between land-use activities and the atmosphere. FCA avoids the definitional issues, in evidence in Article 3.3 of the Protocol, associated with partial accounting systems.

In addition, FCA avoids the complexities, such as gaming, leakage and permanence of GHG benefits, associated with partial accounting systems. Gaming, for example, could result through a partial accounting system if some additional land-use activities are made eligible under Article 3.4, while others are not. Similarly, leakage of GHG benefits may occur through partial accounting systems. Where demand for agricultural land is high, for example, reforestation of agricultural lands could lead to agricultural intensification elsewhere. This transfer of activity could result in soil-carbon losses not captured by a partial accounting system.

FCA offers a superior approach to the permanence issue because it requires continuous monitoring of carbon stocks over contiguous commitment periods. As such, FCA will capture fluctuations in carbon stocks and, where necessary, require GHG emissions from the land-use sectors to be offset. In short, because all emissions on managed lands are captured over contiguous commitment periods under FCA, the reversibility of GHG benefits from land-use activities is not an obstacle to emissions trading.

Adoption of FCA would move the Kyoto Protocol towards a system in which projected emissions and sequestration from the land-use sector would be explicitly considered in the context of adopting assigned amounts for subsequent commitment periods. This avoids the difficulties associated with limiting business-as-usual crediting under the current configuration of Article 3.4. Under FCA, business-as-usual activities can be figured into the establishment of Kyoto emissions budgets. This is of central importance because it alleviates the tension between land-use activities and the stringency of Kyoto targets under Article 3.4, thereby resolving the perception (and an important political problem) that inclusion of carbon-sequestration activities are intended to weaken the Kyoto treaty. Done properly, inclusion of land-use activities will strengthen it.

Finally, in contrast to the current structure of Article 3.4, FCA must be mandatory for all Parties. This is crucial for addressing tropical deforestation as well as for emissions from other land-use activities. Tropical deforestation is the primary source of GHG emissions from many developing nations (e.g. Brazil). As developing countries enter Annex B by adopting emissions budgets, it is vital that they be given incentives to reduce deforestation. Allowing countries with significant land-use emissions to exclude large portions of the land sector would seriously undermine the effectiveness of the Kyoto Protocol. If accounting for land-use activities is to be reflective of atmospheric GHG concentrations and if tropical deforestation is to be confronted in a comprehensive way, FCA cannot be discretionary.

(c) *Capacity building in developing countries*

It is unlikely that developing countries will be willing to take emissions budgets that require FCA unless they gain experience in successfully curbing tropical deforestation while also providing for the needs of their citizens. The CDM provides a unique opportunity for developing countries to gain experience in addressing tropical deforestation. Projects addressing tropical deforestation must be made eligible for the CDM beyond the first commitment period. Negotiators should also consider revisiting the question of forest conservation project eligibility for the first commitment period.

The two greatest threats to the global environment are climate change and loss of biodiversity, the later of which is most severe in areas experiencing high rates of tropical deforestation. The inclusion of land-use activities in a GHG emissions-trading framework through full carbon accounting can potentially leverage substantial financial resources to reduce atmospheric GHGs and protect the Earth's terrestrial ecosystems.

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